OUTLINE SHEET 3-11-1
Propulsion Units

A. Introduction

Different platforms are used by different ships for propulsion. This lesson will familiarize you with the different types of propulsion units.

B. Enabling Objectives

3.30 **STATE** the types and component parts of steam turbines.

3.31 **STATE** the types and component parts of internal combustion engines.

3.32 **STATE** the procedures for operating internal combustion engines in an enclosed space.

3.33 **STATE** the basic types and component parts of gas turbine engines.

C. Topic Outline

1. Introduction
2. Terminology
3. Steam Turbines
4. Internal Combustion Engines
5. Gas Turbine
6. Summary and Review
7. Assignment

ASSIGNMENT SHEET 3-11-2
Propulsion Units

A. Introduction

This material is to be completed prior to the material being covered in class.

B. Enabling Objectives

Refer to enabling objectives in Outline Sheet 3-11-1.

C. Study Assignment

1. Read Fireman NAVEDTRA 12001, Chapters 4-8.
2. Read Information Sheet 3-11-3

D. Study Questions

1. What are the differences between an impulse turbine and a reaction turbine?
2. What are the methods used to prevent leaks along the rotor shaft?
3. What is the difference between a cycle and a stroke in an internal combustion engine?
4. What are the dangers involved in operating an internal combustion engine in an enclosed space?
5. What are the four major sections of a gas turbine engine?

INFORMATION SHEET 3-11-3
Propulsion Units

A. Introduction

This information describes shipboard propulsion units.

B. Reference

Fireman NAVEDTRA 12001
Machinist's Mate 3&2 NAVEDTRA 12144
EN3 NAVEDTRA 10539
NSTM 555 Vol1 Part 2
Gas Turbine Systems Technician 3 (Electrical\Mechanical),
Volume 2 NAVEDTRA 10564

C. Information

I. Terminology
   A. Energy - ability to do work.
   B. Work - moving an object through a resisting force.
   C. Power- the amount of work done over a period of time.

II. Main boilers provide steam to the ship's propulsion turbines and other auxiliary machinery and services.

III. Steam turbines convert heat energy into mechanical energy to perform useful work.
   A. Steam turbines produce the power for propulsion.
   B. They are also used as prime movers for various auxiliary machinery.

IV. Steam turbines may be classified into 2 general groups: impulse turbines and reaction turbines.
   A. Impulse turbines use nozzles to direct steam against the blades. The high velocity steam directly pushing the blades causes the rotor to turn.
   B. Reaction turbines use stationary or fixed blades that act as nozzles to direct steam into the moving blades.
      1. The steam from the fixed blades acting on the moving blades makes the reaction turbine work like an impulse turbine.
      2. The difference is that the moving blades also act like nozzles. The action of the steam leaving the moving blades causes the rotor to turn in the opposite direction of the exiting steam.

V. Component parts of the steam turbine
   A. Foundation - provides a supporting base.
   B. Casing - houses the rotating element of the turbine.

C. Nozzle control valves control the speed of the turbine by controlling the amount of steam admitted.
D. Nozzles are used to convert thermal energy of steam into kinetic energy. Nozzles direct the steam against the blades.
E. Rotors, which carry the moving blades, convert the steam's energy into rotating mechanical energy.
F. Astern elements are used for emergency stopping, backing, and maneuvering.
G. Bearings carry and support the weight of the rotor and maintain radial clearance between the rotor and casing.
H. Shaft packing glands prevent leaks where the rotor shaft extends through the casing.
    1. Labyrinth and carbon rings perform this function and may be used separately or in combination.
    2. Labyrinth packing consists of rows of flat metal strips or fins. The labyrinths are pressurized with gland seal steam to prevent air from entering the casing.
    3. Carbon packing rings mount around the shaft and are held in place by springs.
I. Shrouding are metal strips that cover the ends of the turbine blades. It is used to reduce vibration stress which causes turbine damage.

VI. Internal combustion engine converts heat energy into work. It burns fuel in a confined chamber within the engine. It is also called a reciprocating engine because it uses pistons that employ a back -and-forth motion.

VII. The operation of an internal-combustion engine involves:
A. the admission of fuel and air into a combustion space
B. compression of the charge
C. ignition of the charge
D. expansion of gases that force the piston to move
E. piston movement changed into rotary motion

VIII. Cycle - the sequence of events that takes place in the cylinder of an engine for each power impulse transmitted to the crankshaft. The cycle of a diesel engine involves the following events:
A. Intake of air
B. Compression of air
C. Injection of fuel
D. Ignition and combustion of charge
E. Expansion of gases
F. Removal of waste

IX. A piston in a 4-stroke diesel engine takes four strokes to complete a cycle.
A. In the INTAKE stroke, air is allowed into the cylinder.
B. In the COMPRESSION stroke, air is compressed by the piston, raising the temperature and pressure of air in the cylinder. Fuel is injected into the cylinder at the end of this stroke.
C. In the POWER stroke, the expanding gases will push the piston.

D. In EXHAUST stroke, waste gases are removed from the cylinder.

X. A piston in a 2-stroke diesel engine takes two strokes to complete a cycle.
   A. POWER stroke starts as the rapidly expanding gas pushes against the piston.
      1. As the piston moves downwards, it will uncover air ports at the bottom of the cylinder.
      2. Air is forced through these ports, pushing out waste gases .
   B. COMPRESSION stroke starts as the piston covers the air ports.
      1. The piston compresses the air inside the cylinder raising its temperature and pressure.
      2. Fuel is injected at the end of this stroke.
      3. The high temperature inside the cylinder causes the fuel to ignite.

XI. Component parts of the diesel engine
   A. Cylinder block - supports the liners, head, and crankshaft. Passages are in the block to allow cooling water, lubrication, and air.
   B. Sump and oil pans - used for collecting and holding lubricating oil.
   C. Bearings - support rotating shafts and moving shafts.
   D. Cylinder assembly
      1. Cylinder - houses the piston and provides area for combustion.
      2. Cylinder liner - allows for wear and provides passages for cooling water.
      3. Cylinder head - seals the combustion chamber.
      4. Scavenging air ports - allow for the intake of air to be used in combustion.
      5. Exhaust valves - allow for hot exhaust combustion gases to be expelled.
      6. Camshaft - operates the valves through cam followers and rocker arms; it is geared directly to the crankshaft.
      7. Piston - slides up and down in the cylinder; it is the principle moving component.
      8. Connecting rod - the securing link between the piston and the crankshaft.
      9. Crankshaft - changes the piston's linear or reciprocating motion to rotating motion to drive machinery.

XII. **WARNING:** Do not operate an internal combustion engine in a confined space unless the exhaust gases can be discharged directly to the outside atmosphere.

XIII. Many gas turbine power plants use aircraft jet engines as gas generators. The addition of power turbine and transmission completes the plant.

   A. The gas turbine engine produces hot combustion gases that strike

the turbine wheel. The turbines are similar to the ones used in a steam plant. The wheel reacts to the passage of the expanding gases by rotating.

B. The turbine wheel is connected to the shaft that is in turn connected to the main reduction gear.

XIV. The gas turbine is classified by the type of compressor used and how the power is used.

A. The centrifugal compressor draws air at the center or eye of the impeller and accelerates it around and outward.

B. The axial flow compressor compresses air while keeping the air in the same direction as the shaft.

C. The single shaft gas turbine is primarily used as a prime mover for an electrical generator. The gas turbine shaft is coupled to the generator shaft.

D. The split shaft gas turbine is primarily used for propulsion. The gas turbine produces hot gases that cause the power turbine to rotate. There is no direct mechanical connection between the gas turbine shaft and the power turbine shaft.

XV. The gas turbine engine has 4 major sections.

A. The COMPRESSOR is used to deliver air at the proper velocity and pressure to the combustor.

1. The compressor contains rotors and stators enclosed in the compressor case.
2. It receives air from the air inlet duct and delivers the air to the combustor.

B. The COMBUSTOR contains the combustion chamber where fuel is mixed with air and ignited.

1. The combustor case covers the liner.
2. The dome assembly has small slots and holes to admit primary air and impart a swirling motion for better atomization of fuel.
3. There are also holes in the dome for the fuel oil nozzles to extend into the combustion area.
4. The liner contains many holes and slots throughout its length.
5. Air coming from the compressor is admitted through these holes to protect the liner and cool the gases at the chamber outlet.
6. The outer liner prevents the flames from contacting the combustor housing and the inner liner prevents the flames from contacting the shaft.

C. The High Pressure (HP) TURBINE that drives the gas generator is located directly behind the combustion chamber outlet. The POWER TURBINE powers the ship’s propeller through the reduction gear and shafting.

D. The ACCESSORIES section provides the gas turbine a starting

device, control mechanism, and power takeoffs for the lube oil and fuel oil pump.

1. The starter is used to turn the compressor at sufficient speed to initiate and sustain combustion. Starters may be pneumatic, electric or hydraulic. The most common starter is pneumatic, which is powered by air turbines.
2. The fuel and speed governing system regulates and distributes fuel to the combustion section. It has a speed governor that senses and maintains the desired speed by adjusting the fuel oil flow.
3. The engine rotor drives a gear train that powers various pumps that supply the engine with fuel oil and lube oil.